

REMARKS/ARGUMENTS

Summary

Claims 1 and 6-15 are pending. Claims 2-5 have been canceled. Claims 1 and 6-15 have been amended.

The Office Action objects to the specification due to informalities. Claims 12 and 13 are rejected under 35 U.S.C. §112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Claims 1-3, 9-12, 14, and 15 are rejected under 35 U.S.C. §102(b) as being anticipated by Koch U.S. Patent 6,178,608 ("Koch"). Claims 4 and 5 are rejected under 35 U.S.C. §103(a) as being unpatentable over Koch in view of Heidelberg U.S. Patent 4,491,769 ("Heidelberg"). Claims 6 and 7 are rejected under 35 U.S.C. §103(a) as being unpatentable over Koch in view of Beaman U.S. Patent 4,866,630 ("Beaman"). The Office Action objects to claims 8 and 13 as being dependent upon a rejected base claim, but indicates that the claims would be allowable if rewritten in independent form including all of the features of the base claim and any intervening claims.

Applicant has amended claim 1 to further set forth features of the invention previously pending in claims 2-5. Accordingly, claims 2-5 have been canceled. Applicant has amended claim 12 to further clarify the claimed invention. Applicant has also amended the claims to remove the numerical indices and substitute the routinely used "wherein" for the less common "characterized in that". No new matter has been added. The Examiner's objection and rejections are addressed below in turn.

The Objection to the Specification

The Office Action objected to the specification due to informalities, in particular, because the specification does not include section headings.

Applicant has amended the specification to generally conform it to the format for U.S. patent applications and has accordingly added section headings. A Substitute Specification

and Comparison Copy are submitted herewith. Accordingly, the objection to the specification is obviated.

The Rejection under §112, Second Paragraph

The Office Action rejects claims 12 and 13 under 35 U.S.C. §112, second paragraph, as being indefinite because it is unclear in claim 12 whether the features following the phrase “in particular” are part of the claimed invention. Claim 13 is rejected as depending from rejected claim 12.

Applicant has amended claim 12 to remove the “in particular” language objected to in the Office Action. Accordingly, the rejection under §112, second paragraph, is obviated.

The Prior Art Rejections

The Office Action rejects claims 1-3, 9-12, 14, and 15 under 35 U.S.C. §102(b) as being anticipated by Koch. Claims 4 and 5 are rejected under 35 U.S.C. §103(a) as being unpatentable over Koch in view of Heidelberg. Claims 2-5 have been canceled. However, as the features of claims 2-5 have been incorporated into independent claim 1, these rejections will be addressed in view of claim 1.

Applicant's independent claim 1 is directed to a rotary indexing table that includes a stationary base unit and a plate that is rotatably supported on the base unit. The plate is drivable relative to the base unit by means of a drive that is formed by a plurality of individual drive elements arranged in the circumferential region of the plate. The individual drive elements include individual permanent magnets that are uniformly distributed adjacent to one another along the total circumference of the plate and substantially diametrically opposite one another with respect to the axis of rotation of the plate. The base unit has at least four electromagnets which lie opposite the permanent magnets coupled to the plate.

Accordingly, applicant's novel approach advantageously provides for the use of a plurality of individual electromagnets to power a rotary indexing table. As each electromagnet only contributes a share of the driving force, less powerful and therefore less expensive (i.e.,

commercially available) electromagnets may be used. Even in sum, the plurality of electromagnets are usually much more cost-favorable than brushless ring torque motors, which require large hand-coiled stators for use in a rotary indexing table. Moreover, the use of a plurality of electromagnets allows for easy scaling of the drive mechanism for indexing tables of different sizes or diameters, and also reduces the concentration of heat development so that air cooling is sufficient.

The Office Action acknowledges that Koch alone does not disclose a plate with a carriage ring provided with individual permanent magnets along its total circumference and, in addition, a plurality of electromagnets which lie opposite the permanent magnets, as now recited in independent claim 1 (Office Action, p. 6, lines 2-4). In particular, Koch fails to disclose “individual drive elements arranged in the circumferential region of the plate . . . comprising individual permanent magnets that are uniformly distributed adjacent to one another along the total circumference of the plate” and “[a] base unit having at least four electromagnets which lie opposite the permanent magnets coupled to the plate”, as set forth by claim 1.

The Office Action contends, however, that Heidelberg can be combined with Koch and discloses what is missing in Koch to render obvious applicant’s claims. Applicant respectfully disagrees.

Koch refers to a rotary index table having an outer carriage ring that is driven to rotate about a central support frame by a pair of servo motors (Abstract). Heidelberg refers to a motor/generator having a first ring of permanent magnets that is rotatable about a second ring of switchable electromagnetic poles (Abstract).

Applicant submits that the Office Action has failed to establish a *prima facie* case of obviousness at least because the proposed modification of Koch would impermissibly change the principle of operation of that reference. In fact, the entire design of the Koch rotary index table, save the most basic features of the frame and carriage ring, must be abandoned in order to combine that reference with the disclosure of Heidelberg. The principle of operation of Koch, namely that the carriage ring is driven to rotate by discrete motors mounted on the frame, would

have to be abandoned in favor of a drastically different operating principle, whereby components of the index table must take on roles akin to the interior components of a traditional motor/generator. Such a drastic modification to the operating principle of a system is evidence that the references are insufficient to render obvious applicant's claims. *In re Ratti*, 270 F.2d 810 (CCPA 1959); MPEP 2143.02 (VI).

Independent of the foregoing, applicant further submits that the Office Action has also failed to provided a proper motivation or suggestion—whether from the references themselves, the knowledge of one of ordinary skill in the art, or the nature of the problem to be solved—to modify the Koch rotary index table with the design of a traditional motor/generator illustrated by Heidelberg. Particularly, the Office Action fails to identify any teaching from the references themselves that would suggest to one of ordinary skill in the art the desirability of combining the references in the manner claimed. That is, the Office Action is unable to identify any objective evidence of a teaching or suggestion in Koch to utilize any other design for its rotary drive means. Similarly, no suggestion is identified in Heidelberg that it would be desirable to adapt the Heidelberg motor/generator design for a rotary index table.

Given that the Office Action does not look to the references themselves for a motivation to combine, applicant further submits that the statements of motivation proffered in the Office Action are insufficient to establish such a motivation based on other permissible grounds. The Office Action states:

[I]t would have been obvious to one of ordinary skill in the art at the time of the invention to use the structure taught by Heidelberg within the teaching of Koch for the purpose/advantages of 1) [p]ermitting optimum utilization of the volume (space), 2) [r]educe the angular ranges of rotation, which do not contribute to the flux switching, 3) [t]he maintenance of the machine is rendered easier as it is possible to replace individual inexpensive switching means. (Office Action, page 6, lines 12-19)

Applicant submits, however, that these proffered statements are not the clear and particular statements required to establish a motivation to combine. *See, In re Dembiczak*, 175 F.3d 994 (Fed. Cir. 1999). Rather, they are of the broad and conclusory variety deemed insufficient as evidence of a motivation to combine. *Id.* In particular, applicant notes that the

proffered statements merely list a series of allegedly desirable advantages without clearly and particularly describing how the achievement of the stated advantages necessarily results in a reason for one of skill in the art to select Heidelberg and Koch and combine them in the manner claimed by the applicant, or how such an alleged motivation arises from the general knowledge of the art or the nature of the problem to be solved. *See, e.g., In re Rouffet*, 149 F.3d 1350 (Fed. Cir. 1998) (the examiner must show reasons why the skilled artisan, without knowledge of the invention, would select the elements from the prior art and combine them in the manner claimed); *In re Kotzab*, 208 F.3d 1352 (Fed. Cir. 2000) (particular findings must be made as to the reason for combination); *In re Lee*, 277 F.3d 1338 (Fed. Cir. 2002) (Board cannot rely on conclusory statements but must set forth the rationale for combination). Without showing such an objective teaching leading to the proposed combination, the Office Action cannot satisfy the burden of obviousness. *E.g., In re Dembiczak*, 175 F.3d 994 (Fed. Cir. 1999); *In re Fritch* 972 F.2d 1260 (Fed. Cir. 1992); *In re Fine*, 837 F.2d 1071 (Fed. Cir. 1988).

Therefore, applicant submits that the Office Action has failed to provide a proper motivation or suggestion to combine Koch with Heidelberg. In the absence of such a motivation, any combination of references to achieve applicant's invention is an impermissible hindsight reconstruction guided by applicant's disclosure. *In re Dembiczak*, 175 F.3d 994 (Fed. Cir. 1999)(it is the essence of hindsight to combine references without evidence of a motivation to do so). It should be noted that the mere fact that references can be combined or that the combination is within the capabilities of one of ordinary skill in the art is not sufficient to establish a case of *prima facie* obviousness without a proper motivation to combine. MPEP 2143.01 (III, IV).

Therefore, applicant submits that independent claim 1 is patentable. Accordingly, claims 9-12, 14, and 15 are patentable at least because they depend from patentable claim 1. Claims 6 and 7, which are rejected under 35 U.S.C. §103(a) as being unpatentable over Koch in view of Beaman, are also patentable at least because they depend from patentable claim 1.

The Objection to Claims 8 and 13

The Office Action objects to claims 8 and 13 as depending from rejected claim 1. As the foregoing demonstrates that claim 1 is patentable, the objection to claims 8 and 13 is obviated.

CONCLUSION

In view of the foregoing, applicant submits that this application is in condition for allowance, and a formal notification to that effect at an early date is requested.

If the Examiner believes a telephone conference would expedite prosecution of this application, please telephone the undersigned at (415) 273-8305 (direct dial).

Respectfully submitted,


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Additions appear as Underlined text

Weiss GmbH — Attorney Docket No. 89498
Client No. W2536PUS

A rotary indexing table

SUBSTITUTE SPECIFICATION

ROTARY INDEXING TABLE

Background of the Invention

[0001] The invention relates to a rotary indexing table comprising a stationary base unit and a plate rotatably supported thereon and drivable relative to the base unit by means of a drive.

[0002] Such rotary indexing tables, as are known in various embodiments from the prior art, serve, for example, to transport a plurality of workpieces held on the said plate or on structures arranged thereon in each case by a rotation of the plate from one working or mounting station further to a next working or mounting station.

[0003] Known rotary indexing tables with a direct drive customarily have a drive unit provided at a suitable position which can, for example, consist of an electric motor which must apply substantial torques, in particular with large plate diameters of the structures. For this purpose, it is necessary for motors with a relatively high power consumption to be used which require a relatively complex cooling system such as a water cooling system, on the one hand, and whose procurement is associated with a disadvantageously high economic cost, on the other hand.

Summary of the Invention

[0004] An object of the present invention consists of providing a rotary indexing table of the initially named kind which, in particular to the extent its drive unit is affected, can be realized with a comparatively low economic effort.

The drive should preferably require such a low power consumption that a cost-favorable air cooling system is possible.

[0005] In accordance with the invention, this object is satisfied in that the drive is formed by a plurality of individual drive elements arranged in the circumferential region of the plate.

~~It~~**[0006]** ~~The object~~ is achieved by ~~this~~a surprisingly easy measure, which was not, however, used in known rotary indexing tables to date, ~~that instead,~~
Instead of an individual, relatively powerful drive element, a plurality of individual drive elements are used which can be made correspondingly less powerful and which accordingly also cause a lower power consumption and, resulting from this, also a lower heat production. These advantages are also achieved in accordance with the invention in that the individual drive elements are not, for instance, arranged in the region of the axis of rotation of the plate, but rather in its circumferential region so that, on the operation of the rotary indexing table in accordance with the invention, comparatively low tangential forces produced in the region of the individual drive elements produce large torques. The individual drive elements can thereby be kept small, which then - as already mentioned - results in an advantageously low power consumption and an accordingly low heat development.

[0007] In accordance with the invention, a plurality of smaller, cost-favorable individual drive elements can therefore be used whose total procurement costs lie under the procurement costs of a single, comparatively large drive element for previously known rotary indexing tables. It is furthermore possible in accordance with the invention, due to the low heat development, only to use a cost-favorable air cooling system on the individual drive elements so that previously required, complex cooling methods can be omitted.

[0008] It is of advantage for the individual drive elements to be arranged in equal distribution at least over part of the circumference of the plate, with them lying substantially diametrically opposite one another in particular with

respect to the axis of rotation. In such an arrangement, the radial forces produced by the individual drive elements are largely canceled out by the respectively oppositely disposed individual drive element without the bearing of the rotary indexing table being significantly strained.

[0009] The individual drive elements can, for example, be formed as electric motors each provided with a toothed wheel, with the toothed wheels engaging into a turntable connected to the plate. In this case, however, mechanical transmission elements are required, namely toothed wheels and a turntable, so that it is preferred for the plate to be provided along its total circumference with individual permanent magnets adjacent to one another which cooperate with electromagnets attached to the base unit, with these electromagnets lying opposite the permanent magnets coupled to the plate. The latter embodiment of the individual drive elements can be realized in a particularly cost-favorable manner and furthermore has the advantage that no mechanical connection has to be provided between the base unit and the plate - and accordingly also no mechanical transmission element - in the region of the individual drive elements since the forces to be applied to the plate can be transmitted in a non-contact manner as electromagnetic forces. Such an electromagnetic drive works largely wear-free in comparison with a gear drive, whereby the service life of the individual drive elements can be substantially increased in an advantageous manner.

[0010] The individual drive elements provided in accordance with the invention are preferably acted on by an air cooling system, with a respective air cooling element being ~~able to be~~ provided, for example, for each half of the individual drive elements arranged in the circumferential region of the plate. It is of technical construction advantage in this process for the two air cooling elements to be provided adjacent to one another and for either a single, joint exhaust air aperture or a respective separate exhaust air aperture to be associated with both air cooling elements. The air cooling elements and the exhaust air apertures can, in this process, be arranged lying substantially diametrically opposite one another with respect to the axis of rotation of the

plate so that it is ensured that substantially the total circumferential region of the plate is uniformly vented.

[0011] To determine the respective position of the plate relative to the base unit and to communicate corresponding information, for example, to a control computer, it is of advantage for an encoder to be provided for the determination of the relative position between the plate and the base unit. Such an encoder can work, for example, with code markings attached to the plate and distributed over its circumference. These code markings can be made either the same as one another or different to one another, with it being advantageous with code markings the same as one another for at least one reference mark to be provided in the region of the code markings so that not only relative movements between the plate and the base unit can be determined, but also an absolute angular position of the plate can be determined. To detect the said-code markings or reference marks, the base unit is provided with an optical, magnetic or inductive sensor.

[0012] It is furthermore of advantage for the base unit to have a brake unit which cooperates with the plate, is in particular acted on by compressed air and by means of which a rotational movement of the plate can be braked immediately and completely, in particular when an emergency occurs. It is preferred in this process for the brake unit to be in its state permitting a rotation of the plate when the compressed air load is present. In this case, namely on a sudden loss of compressed air, for example, a braking of the plate is triggered.

[0013] The plate and the base unit can each be made in ring shape, with the central openings of the plate and of the base unit being substantially aligned with one another. This makes it possible for workpieces arranged on the plate to be able to be worked not only starting from the circumferential region of the plate, but also starting from the said-openings, since working apparatuses can be provided both in the circumferential region of the plate and in the region of the said-openings.

[0014] It is finally preferred for the plate to be supported rotatably via a wire four-point bearing on the base unit irrespective of whether it is circular or in the form of a circular ring. Such a bearing is particularly easily suited to transmit radial forces, tangential forces and vertical forces between the plate and the base unit.

[0015] Further preferred embodiments of the methods are described in the dependent claims. following detailed description and drawings.

Brief Description of the Drawings

[0016] The invention will be described in the following with reference to an embodiment and to the drawings; ~~there are shown in these:~~

[0017] Fig. 1 is a three-dimensional view of a possible embodiment of a rotary indexing table in accordance with the invention in which the plate has been left out regionally in order to make the interior of the rotary indexing table visible; ~~and~~

[0018] Fig. 2 illustrates a section through a rotary indexing table in accordance with Fig. 1; and

[0019] Fig. 3 is a three-dimensional view of a region of a ring element supporting the plate with individual drive elements arranged thereon.

Description of the Preferred Embodiments

[0020] Fig. 1 shows a rotary indexing table comprising a plate 10 which is made in circular ring shape, is only shown regionally in Fig. 1 and is rigidly connected to a ring element 9, with the ring element 9 being located completely beneath the plate 10. A corresponding arrangement is visible from Fig. 2 which shows a section through an arrangement in accordance with Fig. 1, with joint reference being made in the following to Figs. 1 and 2.

[0021] The ring element 9 with the plate 10 is rotatably supported on a base unit 16, with the base unit 16 i.a. having a ring-shaped support profile 17 (Fig.

2) to which the further elements of the base unit 16 are attached. The central opening of the support section 17 is approximately as large as the central opening of the plate 10.

[0022] A wire four-point bearing 8 is formed between the support section 17 and the ring 9 and consists of four wires 18 which extend in circular form and parallel to one another and are arranged ~~such~~so that they form a cage for balls 19 arranged inside these wires 18. Such wire four-point bearings 8 are particularly well-suited to transmit forces acting both vertically, that is, parallel to the axis of rotation of the plate 10, and radially to the plate 10 between the ring element 9 and the support section 17.

[0023] The dimensions of the rotary indexing table shown in Figs. 1 and 2 have been selected ~~such~~so that the diameter of the central opening of the plate 10 and of the support section 17 is approximately half as large as the total diameter of the rotary indexing table shown. The vertical extent of the rotary indexing table amounts to somewhat less than a quarter of its diameter. In other embodiments of the rotary indexing table in accordance with the invention, however, any desired other size ratios can be realized depending on the application case.

[0024] Seals 11, 12 are formed between the plate 10 and the base unit 16 and prevent penetration of contamination into the interior of the rotary indexing table and an escape of lubricants from the bearing 8.

[0025] Individual permanent magnets 2 which are uniformly distributed adjacent to one another are provided in the circumferential region of the ring element 9 and are each made in bar shape and extend parallel to the axis of rotation of the plate 10. A plurality of electromagnets 1, for example twelve, are provided outside the ring element 9, opposite the permanent magnets 2, and six pieces of them are shown in total in Fig. 1. The electromagnets 1 are arranged substantially uniformly distributed in two drive regions of the outer circumference of the ring element 9, with the two ~~said~~ drive regions each extending over somewhat less than 180°, but over much more than 90° of the

circumference of the ring element 9. In this process, the electromagnets 1 are fixedly connected to the base unit 16 and are arranged ~~such~~so that they can cooperate with the bar-shaped permanent magnets 2 which are fastened to the rotatable ring element 9. In other larger embodiments of the invention, it is possible without problem to provide twenty or more electromagnets 1.

[0026] The ring element 9 is provided above the permanent magnets 2 with code markings 4 (Fig. 2) which are arranged adjacent to one another and which pass a measuring head 3 on a rotation of the plate 10 or of the ring element 9, ~~said the~~ measuring head being fixedly connected to the base unit 16. The measuring head 3 can be made as an optical, a magnetic or as an inductive sensor. Since the code markings 4 i.a. also include at least one reference mark, the respective position of the plate 10 can be absolutely determined via the measuring head 3.

[0027] The measuring head 3, like two fans 13, 13' adjacent to it, is provided in a circumferential region of the support section 17 in which no ~~electromagnetieselectromagnets~~ 1 are arranged. The two fans 13, 13' are each approximately associated with a semi-ring space of the rotary indexing table shown in Figs. 1 and 2 ~~such~~so that each fan 13, 13' ventilates a total of six electromagnets 1 in each of one of the aforesaid drive regions .

[0028] A further circumferential region of the support section 17 is provided opposite the fans 13, 13' and the measuring head 3 and no electromagnets 1 are present in it. An energy supply 15 is provided in this region via which the electromagnets 1 can be supplied with energy. One exhaust air aperture 14 each is provided at both sides of the energy supply 15 and is in each case suitable for ~~the~~ transporting away the air sucked in by a fan 13, 13'. Only one of these two exhaust air apertures 14 can be seen in Fig. 1 due to the only partially not shown plate 10.

[0029] A compressed air connection 6 (Fig. 1) is furthermore located in that region of the rotary indexing table in which the energy supply 15 is provided and compressed air can be supplied via it to a brake unit 5 which is associated

with the ring element 9 in the region of the energy supply 15. On being loaded with compressed air, the brake unit 5 releases the ring element 9 so that it can rotate freely with respect to the base unit 16. On a drop of compressed air, the ring element 9 is braked by brake shoes of the brake unit 5.

[0030] Fig. 3 shows a section of the ring element 9 with permanent magnets 2 arranged thereon. A multiple of motor metal sheets 1b are provided opposite the permanent magnets 2 and are each connected to the base unit 16 in a manner not shown. One electromagnet 1 each with a motor winding 1a is fastened on each of these motor metal sheets. To better illustrate this design, a motor metal sheet 1b is shown in Fig. 3 without an electromagnet 1 fastened thereto and an electromagnet 1 is shown with and without a housing 7.

[0031] On operation of the rotary indexing table shown in Figs. 1 to 3, all electromagnets 1 are charged with current via the energy supply 15 suchso that a rotation of the ring element 9 or of the plate 10 is triggered with respect to the base unit 16 due to the electromagnetic forces between the electromagnet 1 and the permanent magnets 2. The respectively desired angular step can be determined via the measuring head 3, for example in that a charging of the electromagnetic 1 is interrupted by a control unit (not shown) as soon as the angular step desired and determined by the measuring head 3 has been carried out.

[0032] Due to the provision in accordance with the invention of a plurality of electromagnets, these - considered individually - must only produce relatively low forces, since all electromagnets 1 cooperate on a rotation of the plate 10 and the forces produced by them are summed accordingly. This has the result that relatively cost-favorable electromagnets can be used which also have only a comparatively low heat development so that the air cooling system shown in Figs. 1 and 2 is sufficient for an operation of the rotary indexing table in accordance with the invention.

[0033] If a rotary indexing table is required in which the plate 10 is rotatable with lower forces with respect to the base unit 16, some of the electromagnets

1 shown can be omitted without problem. It would, for example, be possible only to provide every second electromagnet 1 shown in Fig. 1. In an extreme case, only two electromagnets 1 are coupled to the base unit 16.

Reference symbol list

1	electromagnet
1a	motor winding
1b	motor metal sheet
2	permanent magnet
3	measuring head
4	code markings
5	brake unit
6	compressed air arrangement
7	housing
8	bearing
9	ring element
10	plate
11	seal
12	seal
13	fan
13'	fan
14	exhaust air aperture
15	energy supply
16	base unit
17	support section
18	wires
19	balls